Growth of group III-AsSb alloys for optoelectronics and electronics by MOCVD

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We are exploring the growth group III-AsSb alloys by metal-organic chemical vapor deposition (MOCVD) for a variety of applications, ranging from long wavelength lasers and photovoltaics to transistor structures. Our efforts have investigated growth on lattice matched substrates (GaSb and InAs) as well as lattice mismatched growth on GaAs in an Emcore D75 high-speed rotating disk MOCVD reactor.

We will present results of growth studies, which have varied growth temperature, V/III, and growth rate, of both GaSb homoepitaxy and heteroepitaxy on GaAs that can be understood within a thermodynamic growth model. Optimum growth conditions will be presented. Our work included growth of the In and Al ternary and quaternary alloys. Different Sb and As source precursors were evaluated for the growth of these alloys. Trimethylantimony (TMSb) is superior to triethylantimony (TESb) for growth of GaSb and In(Ga)AsSb, while TESb gives lower background carbon concentrations in Al(Ga)AsSb. AsH_3 mixtures were determined to produce higher background oxygen concentrations than pure AsH_3. We have also explored the doping of these materials using diethyltellurium, tetraethyltin, and diethylzinc. Sn and Te form donors with low electrical activities varying from 90% for InGaAsSb to 1% for AlGaAsSb, while Zn forms a well behaved acceptor with a high activation (≅100%). We have also grown superlattices and quantum wells of (AlGa)AsSb/GaSb and In(Ga)AsSb/GaSb. Characterization of these structures by x-ray diffraction shows the effects of growth conditions on interfaces. Optical characterization by photoluminescence will also be presented.

Our efforts concerning heteroepitaxy have included investigations of GaSb and InAs nucleation on GaAs. We have investigated the formation of quantum confined nanostructures. Growth conditions for these structures will be presented along with structural and optical characterization. AFM was used to study the nucleation of GaSb on GaAs as a function of deposit thickness. These results show the island sizes depend on growth temperature and V/III ratio. Interest in the integration of GaSb-based transistor circuits on GaAs substrates has driven research into heteroepitaxy of GaSb on GaAs to form thick layers of relaxed GaSb. Our results suggest that GaSb grown on (100) substrates retains a significant amount of strain, while films grown on miscut surfaces display significantly reduced strain. X-ray diffraction results will be presented to explain this effect.

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